Soybean Diseases in Illinois

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When the soybean was first introduced into this country, it was notably free from serious diseases. As soybean acreages expanded, however, diseases also increased in number and severity. Some were new diseases; others were introduced from the Orient, where they had been known for many years.

In 1943, the U.S. Department of Agriculture, in cooperation with the Illinois and other state agricultural experiment stations, began a coordinated research program on soybean diseases. An important objective in this program is finding sources of disease resistance that can be used by plant breeders. The most economical method of controlling diseases of field crops is through the use of disease-resistant varieties.

Although considerable time and money are expended in developing a resistant variety, the cost to the grower after its release is no more than that of the susceptible variety it replaces. The advantage of this method — an important one with the growing concern for air and water pollution — is that no chemical is added to either soil or air.

About 50 diseases are known to affect soybeans over the world, but only those diseases that are important in Illinois will be discused in this circular. These diseases are divided into groups based on symptoms: Diseases of the Stem and Root, General Diseases of the Aerial Parts, Leafspot Diseases, and Seed and Seedling Diseases. Some of these diseases attack parts of the plant other than the one under which they are listed. For example, bacterial blight can affect pods, stems, and leaves, but the outstanding and most common signs of the disease are the leaf symptoms. For this reason, bacterial blight is listed under Leafspot Diseases.

DISEASES OF THE STEM AND ROOT

Brown Stem Rot

Brown stem rot, caused by the fungus *Cephalosporium gregatum* Allington and Chamberlain, was discovered in 1944 in central Illinois. It currently ranks as one of the most important soybean diseases in the state. The fungus enters the plant through the root and lower stem and travels slowly upward. At first, infected plants show no outward symptoms. In late summer, however, if the stem is split lengthwise, a brown discoloration can be detected inside the stem, primarily in the vascular (woody) tissue. This internal browning later becomes visible in the central portion of the stem (pith). It is the only symptom that identifies the disease as brown stem rot at this stage (Figure 1).

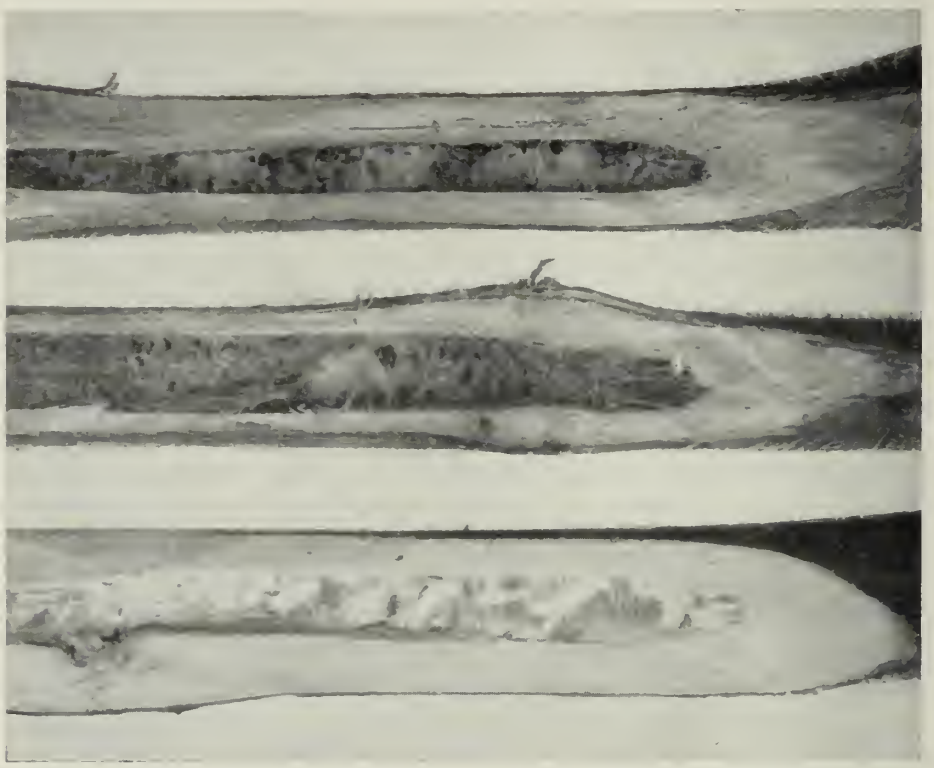

Figure 1. *Brown stem rot (stem symptoms).* The soybean stems at top and center show the dark brown internal discoloration characteristic of this disease. The stem at bottom is normal. Brown stem rot is currently one of the most serious soybean diseases in Illinois. It can be controlled by rotating crops.

During dry periods, leaf symptoms sometimes appear before maturity. The leaf tissues between the veins turn brown, with a narrow green border persisting along the veins for a few days (Figure 2). The entire leaf may wither. The soybean field assumes a brownish cast in contrast with the yellow-green color of a normally maturing field. Leaf symptoms are not common, however, and cannot be relied upon to indicate brown stem rot. The stem should always be split to confirm the presence of the disease.

The loss in yield caused by brown stem rot varies with the amount of infection. If all of the plants are infected, the loss may amount to 25 percent. The disease is soil-borne. The only available control measure is a rotation in which soybeans are grown on the same land only once in three years. There appears to be a prospect for resistant varieties in the future. A type of resistance has been found in two strains from Korea and Japan that have been crossed with several established varieties.

Charcoal Rot

Charcoal rot is a disease that is usually noticed after midsummer, especially in the southern half of Illinois. When the root and base of the stem are split open, they show black streaks in the woody portions. The tiny black bodies (sclerotia) can be seen when the bark is peeled from the root and base of the stem. They resemble a sprinkling of finely powdered charcoal (Figure 3).

For many years, charcoal rot was considered a disease of mature plants that usually appeared during hot, dry weather. Recent work at the Missouri Agricultural Experiment Station has shown that young plants may become infected long before the disease is detected, and that high temperature and arid conditions are not necessary for infection. Charcoal rot is caused by the fungus *Macrophomina phaseolina* (Tassi) Goid.

Phytophthora Rot

In 1955, a root and stem rot that affects soybean plants at almost all ages appeared in northern and central Illinois. Seedlings may be killed before they emerge from the soil or may wither and die immediately after emergence. On older plants, the most common symptom is a chocolate brown girdling discoloration on the stem that soon causes the plant to wither and die (Figure 4).

Root damage may vary from a partial browning to a rot of almost the entire root system. The disease is more frequently seen in low areas of a field where water tends to accumulate. In very wet seasons, however, the disease may invade higher ground. It is more severe on heavy clay soils.

Figure 2. *Brown stem rot (leaf symptoms).* The center leaflet shows early stages of blighting. The leaflets at top and bottom show advanced stages.

Figure 3. *Charcoal rot.* The bark of the stems has been peeled back to show the tiny black bodies (sclerotia).

Figure 4. *Phytophthora rot.* The stem and bases of the lower branches show the dark brown discoloration characteristic of this disease.

Phytophthora rot is caused by *Phytophthora megasperma* var. *sojae* A.A. Hildeb.

Phytophthora rot can usually be distinguished from Rhizoctonia root rot by color. Phytophthora-infected roots are a dark brown. Rhizoctonia-infected roots are usually reddish brown. Young plants are susceptible to quick killing by Phytophthora, but older plants are killed more slowly. Leaves and stems can also be infected by splashing water from contaminated soil.

The disease is well controlled by the use of resistant varieties available for all areas of adaptation in Illinois. Chippewa 64, Steele, Amsoy 71, Harosoy 63, Lindarin 63, Beeson, Protana, Harwood, Calland, Clark 63, Bonus, and Cutler 71 are highly resistant to Phytophthora rot.

Pythium Rot

The symptoms of Pythium rot are somewhat similar to those of Phytophthora rot. Pythium can kill the germinating seed, the young seedling plants, and even older plants later in the season. In cold soil, Pythium causes seed rot and damping-off of young seedlings before and after emergence. Seedlings that emerge with normal cotyledons (seed leaves) may have a dead terminal growing point. These seedlings are known as "baldheads."

In older plants, the tissues in the stem and upper root appear water-soaked. The cortex (outer bark) of the stem and main root is brown, moist, and tends to slough off. Smaller roots are rotted. Two species of the organism, *Phythium debaryanum* Hesse and *Pythium ultimum* Trow, cause the Pythium rot.

The disease is favored by cold, wet soil early in the growing season. Rotation is of no value in controlling Pythium rot because this disease affects a wide range of crop plants. There are no resistant varieties.

Rhizoctonia Root Rot

A root and basal stem rot of soybeans appears occasionally in Illinois early in the season. It produces a reddish brown decay in the outer layer of the root and the base of the stem of young plants (Figure 5). The plants wilt and then die. The dead plants appear in areas several feet in diameter, usually scattered irregularly over the field.

The disease seems to be aggrevated by cool, wet weather early in the growing season. Rhizoctonia root rot has not been sufficiently widespread in the state to be considered a major disease. It is caused by *Rhizoctonia solani* Kuehn.

Figure 5. *Rhizoctonia root rot.* The darkened areas on the roots are the reddish brown lesions typical of this disease. The basal tap root of the plant on the right has decayed and broken off the root. Rhizoctonia root rot is not a major disease in Illinois.

Sclerotinia Stem Rot

Another disease, not to be confused with brown stem rot, is Sclerotinia stem rot. This disease can be recognized by a white, cottony mass of fungus growth, usually on the lower part of the stem. As the disease progresses, large black sclerotia develop within the white mass (Figure 6). These are much larger than the sclerotia produced by the charcoal rot organism. If the stem is split open, sclerotia may be found in the pith. They also form in the pods. The affected plants are killed by the disease. The inside of the stem is not brown.

Sclerotinia stem rot is not a common disease in Illinois, but it has caused occasional severe damage in other states. There are no known control measures. The causal fungus, *Sclerotinia sclerotiorum* (Lib.) d By., is better known for its damage to some vegetable crops.

Although the damage caused by Sclerotinia rot to soybeans in Illinois fields has been negligible, the disease can cause economic loss of another kind. Japan has established a zero tolerance for sclerotia in soybeans inspected at Japanese ports. In 1963, an entire shipload of soybeans from the United States had to be recleaned at the shipper's expense because an inspector found sclerotia in the shipment. Since samples of the Illinois-grown soybeans were free of sclerotia, it was assumed that the sclerotia came into the shipment with beans from other states.

Figure 6. *Sclerotinia stem rot.* The six black bodies at left are the sclerotia. The stem at left shows white masses of fungus growth with imbedded sclerotia. The split stem at right shows black sclerotia in the pith. Sclerotia stem rot is not a common disease in Illinois.

GENERAL DISEASES OF THE AERIAL PARTS

Pod and Stem Blight

Pod and stem blight commonly occurs over the entire state. Symptoms appear on plants nearing maturity. The disease is identified by the small black fruiting bodies (pycnidia) that appear on the stems and pods of infected plants (Figure 7). The pycnidia are arranged in linear rows on the stem. Pod and stem blight is caused by *Diaporthe phaseolorum* var. *sojae* (Lehman) Wehm.

It now seems likely that seed infection is the most serious phase of pod and stem blight. Infected seed may be shriveled, moldy, and smaller than normal, or they may appear entirely healthy but germinate poorly. Lesions may appear on the cotyledons of infected seed. These lesions vary from pinpoint size to almost the size of the cotyledon itself. The color of the lesion varies from light brown to red.

The Diaporthe fungus does not survive long periods in stored seed. Research by Canadian workers has shown that the number of infected seed was greatly reduced and germination of the seed was considerably improved after two years' storage at 10° C. Crop rotation is the recommended control measure.

Stem Canker

Stem canker may occur anywhere in the state. It usually appears after mid-July and persists until the crop matures. The first indication of the disease is the appearance of dead plants with leaves still attached. Upon closer examination, these plants show a slightly sunken brown girdling area on the stem at the base of a branch or leaf stalk (petiole). In general, these infections are close to the soil line, but occasionally they are higher up on the stem (Figure 8). During rainy seasons, high percentages of diseased plants have been found in Illinois fields where crops of soybeans have been grown year after year.

Stem canker does not generally kill all of the plants over a large area, but occasional dead plants may usually be found. The disease is caused by the fungus *Diaporthe phaseolorum* var. *caulivora* Athow and Caldwell, a fungus closely related to the pod and stem blight organism. Since both organisms overwinter on infected stems and seeds, the recommended control measures are the same: rotation, clean seed, and complete plowing under of crop refuse. The variety Harosoy is less susceptible in the field than most other varieties.

Figure 7. *Pod and stem blight.* The fruiting bodies (considerably enlarged) on stem and pod. This disease is widespread in Illinois. Crop rotation is the recommended control measure.

Figure 8. *Stem canker*. The canker (light area on the stem) girdles the stem and kills the plant. The branch at the base of which the lesion occurs dies first; then the entire plant above the lesion dies. Stem canker appears during late July and August.

Bud Blight

Of the three virus diseases that affect soybeans — bud blight, mosaic, and yellow mosaic — bud blight is the most serious. It is caused by the tobacco ringspot virus (the tobacco streak virus causes nearly identical symptoms). Bud blight may attack plants throughout the growing season. The first symptom, from which the disease gets its name, appears on young plants. It is a browning and curling of the terminal bud to form a crook (Figure 9).

The bud becomes dry and brittle, and the leaf immediately below it shows a flecking of rusty brown specks. Sometimes the inside of the stem at the upper nodes turns brown. The infected plant is stunted and produces no seed. Soybeans infected later in the season may produce no pods or small, undeveloped ones. Plants affected in either of these ways are known as "duds." They are easily recognized in the fall because they remain green after normal plants have matured.

Later infection produces another type of symptom. The pods may be poorly filled and drop prematurely (Figure 10), or they may be covered with purple blotches and remain on the plant. Bud blight has caused serious losses in some fields, especially in southern and south central Illinois. The disease usually appears first at the edges of a field and progresses inward, suggesting that an insect carries the virus. Grasshoppers and young thrips (nymphs) can transmit the virus to some extent, but neither appears to have much potential for spreading the virus on a large scale. There is no known effective control measure.

The time of infection determines whether the virus is seed-borne. When soybeans are infected before flowering, the virus invades the seed. Since these infected plants produce very few seed, however, there is no likelihood of serious spread of the disease from seed. Plants infected after flowering do not produce infected seed.

Soybean Mosaic

Soybean mosaic appears to a limited extent throughout Illinois. Thus far it has been a minor disease that has caused no serious damage in the state. The leaves of plants infected with mosaic are distorted and narrower than normal, and their margins turn downward. They may have a yellowish cast, and usually show a dark green, blister-like puckering along the veins (Figure 11). Under certain conditions, the leaves may be severely distorted. The infected plants usually show some stunting.

As the summer advances and the weather gets warmer, oil-type soybean varieties show progressively less evidence of the disease, and the new leaves are practically free of the distortion observed earlier in the season.

Figure 9. *Bud blight (early symptoms).* Left, curling of the terminal bud (arrow). Right, distortion, dwarfing, and flecking of the youngest leaves on an older plant.

Figure 10. *Bud blight (later symptoms).* Immature pods, poorly filled and discolored, that have fallen from plants. This condition may occur if infection sets in shortly after the pods are formed. When infection sets in later, dark purple spots appear on the pods.

Figure 11. *Soybean mosaic*. The leaflet at top and the leaflets in the center show typical puckering and distortion. A normal leaflet is shown at bottom. Thus far soybean mosaic has not caused serious damage in Illinois.

Certain varieties continue to develop leaf distortion throughout the season.

The herbicide 2,4-D induces a leaf distortion on soybeans quite similar to that of soybean mosaic. Careless handling of 2,4-D sprays in the vicinity of soybean fields, especially on windy days, may damage the leaves of plants 200 feet away from the actual site of application.

In recent years, another aspect of mosaic has been reported. Under cool growing conditions and situations favoring heavy natural insect transmission, mosaic-infected plants produce mottled seed. The quality may be downgraded and the prices discounted because of high percentages of mottled seed in a shipment. The black or brown pigment in the seedcoats is objectionable in food products made from soybeans, especially in foreign trade.

Mosaic is seed-borne and transmitted by insects. Although it is not currently an important disease, infected plants should be rogued from the field where soybeans are grown for seed. It is caused by *Soja virus* 1.

Yellow Mosaic

In 1948, yellow mosaic was first recognized as a disease distinct from common mosaic. The leaves of infected plants are free from the extreme distortion and puckering characteristic of common mosaic. The younger leaves show a yellow mottling (Figure 12). This mottling may be random spots over the leaf blade, an indefinite yellow band along the major veins, or isolated yellow spots between the veins. Rusty spots of dead tissue appear later on the yellow portions of the leaves as the plants approach maturity. Usually, the plants are not noticeably stunted.

There is no evidence that the virus is seed-borne. It is widely distributed over the state but has not caused any appreciable damage. Yellow mosaic is caused by *Phaseolus virus* 2.

LEAFSPOT DISEASES

Bacterial Blight

Bacterial blight, one of the most widespread diseases in Illinois, is caused by *Pseudomonas glycinea* Coerper. The organism is seed-borne.

Bacterial blight is usually one of the first leafspot diseases to appear on young plants. It is favored by cool, rainy weather. Small, angular spots varying from yellow to brown develop on the leaves of infected plants. The brown central area of these spots is usually surrounded by a water-soaked margin. The spots later dry and become brown and sunken. They are frequently surrounded by a narrow yellow border that is more noticeable on the top side of the leaf.

Figure 12. *Yellow mosaic.* These leaflets show the various kinds of yellow mottling typical of the disease.

Under certain conditions, the infection travels especially along the veins, followed by death and breaking of the tissues. The leaves then have a torn, ragged appearance (Figure 13). Since beating rain may also cause leaves to become ragged, appearance alone should not be considered a disease symptom.

Bacterial blight usually develops most extensively in cool weather. When windy rainstorms occur frequently through July, however, new blight infections may appear on the young leaves until mid-August. Although the disease is most commonly found on the leaves, it can also affect stems, petioles, and pods.

Susceptibility to the disease varies considerably among soybean varieties. There are currently no resistant varieties. Breeding for resistance to bacterial blight is complicated by races of the organism that differ in their ability to infect various soybean varieties. All varieties grown in Illinois are susceptible.

Bacterial Pustule

Bacterial pustule is primarily a disease of the leaves, although it may sometimes infect the pods. The first symptoms are small yellow-green spots with reddish brown centers. These spots are most conspicuous on the upper surface of the leaf. The central portions of the individual spots appear slightly raised. These develop into small pustules, especially on the underside of the leaf (Figure 14).

Many infections on the same leaf produce a large, yellow-to-brown area dotted with small, darker brown spots. The brown, dead areas of older leaves frequently break up; the leaves then have a ragged appearance. In later stages, the pustules rupture and dry. When rupturing and drying occur, it may become difficult to distinguish this disease from bacterial blight. In the early stages, however, bacterial blight develops a narrow, water-soaked area around the center of the spot, while bacterial pustule does not. Bacterial pustule is caused by *Xanthomonas phaseoli* var. *sojensis* (Hedges) Starr and Burkholder. Severe infection often causes plants to lose their leaves.

The disease is carried over from year to year in infected leaves, and may be borne on the seed. It is a warm-weather disease, usually appearing in Illinois in July. Bacterial pustule is not an important problem in areas north of Urbana-Champaign. Consequently, the emphasis in breeding for resistance to bacterial pustule is concentrated on varieties adapted to the southern half of the state. Clark 63, Wayne, and Williams are resistant to bacterial pustule.

Figure 13. *Bacterial blight.* The leaflet at upper right shows damage by shredding. The leaflet at upper left shows small, angular spots and larger brown areas caused by small infections running together. The leaflet at bottom shows the advanced stage, with dead areas falling out.

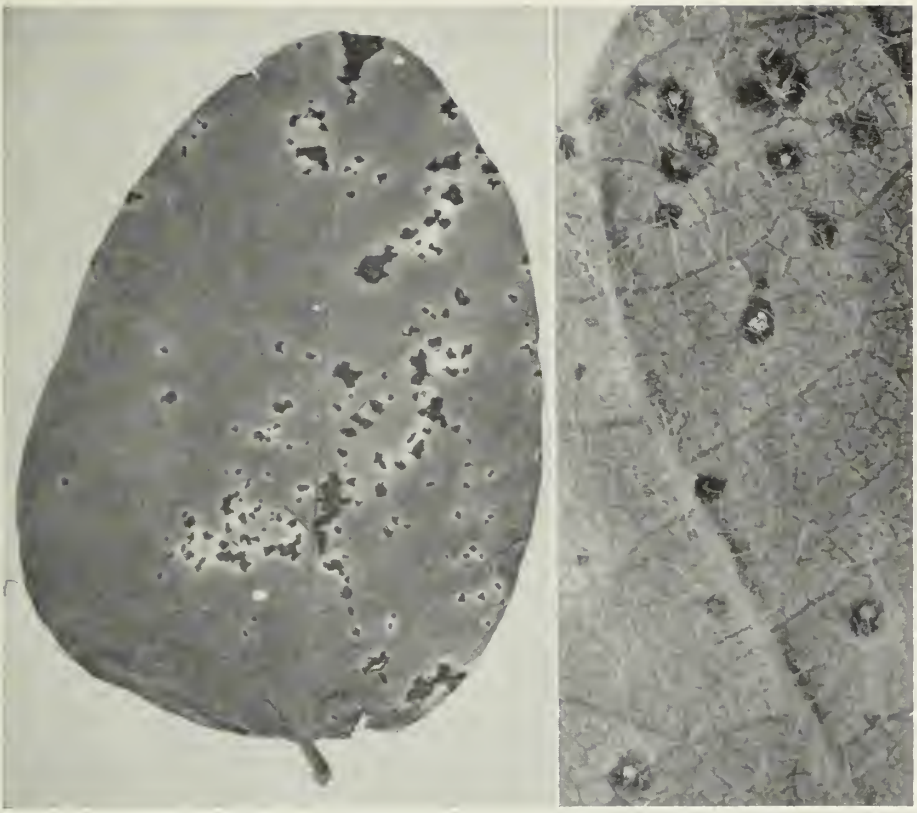

Figure 14. *Bacterial pustule.* Left, symptoms as they appear on the upper surface of a leaflet. Right, enlarged view of the underside of an infected leaflet. The light spots that appear in the middle of the dark areas are pustules, almost too small to be seen with the naked eye.

Wildfire

Wildfire is a bacterial leafspot that appears occasionally on soybeans in Illinois. It has been known for years as a serious disease of tobacco, but was first noticed on soybeans in the field in 1943. The symptoms are strikingly different from those of other soybean diseases. Prominent yellow halos with well-marked margins develop around a central area of brown, dead leaf tissue (Figure 15).

The brown area may increase to involve a large portion of the leaf. Wildfire is closely associated with bacterial pustule, and appears only in years when bacterial pustule is plentiful. A bacterial pustule can usually be found in the center of a wildfire lesion.

Figure 15. *Wildfire*. Leaflets showing typical symptoms. The central areas of the lesions are surrounded by distinctive yellow halos. The large dark patches are lesions that have run together. On old infections, the halos may disappear. The disease cannot then be identified by symptoms. Wildfire has been a minor soybean disease in Illinois.

Thus far wildfire has been a minor and infrequent disease in Illinois, causing little damage to soybeans. It will bear close attention, however, since it causes considerable damage in the southern states. Wildfire is caused by *Pseudomonas tabaci* Wolf and Foster. Since wildfire is closely associated with bacterial pustule, pustule-resistant varieties such as Clark 63, Wayne, and Williams should also provide field resistance to wildfire.

Brown Spot

Brown spot has become an important disease in Illinois. It is one of the earliest diseases to appear on soybeans in the spring. The symptoms are angular, reddish brown spots on the first pair of leaves to come out (Figure 16). The reddish brown color is more pronounced on the under than on the upper leaf surface. There is no water-soaked or yellow mar-

Figure 16. *Brown spot*. Top, leaflet with moderate infection; center, severe infection; and bottom, very severe infection. As the infection progresses, the leaves turn yellow and finally drop. Crop rotation is the only control measure.

gin. As the plant grows, the disease moves upward to the younger leaves. Infected leaves gradually turn yellow and are shed prematurely.

In badly infected fields, the lower half of the stem may lose all of its leaves. Although brown spot is most conspicuous on the leaves, it also causes brown discolorations on stems, branches, and pods. These lesions or specks vary from dots the size of pinpoints to those about one-eighth of an inch long. When these small dots join one another, however, the spots may become much larger.

The fruiting bodies (pycnidia) of the fungus are borne in the tissues of the leaf and stem. They can be seen only with the aid of a hand lens. The spores are discharged to the surface through a comparatively large pore, and spread infection to new leaves or other plants.

Warm, moist weather and poor drainage favor the spread of the disease. The fruiting bodies overwinter on diseased leaves and stems. They serve as a source of infection if soybeans are grown on the same land the next year. Work at the North Carolina Agricultural Experiment Station indicates that the disease is seed-borne.

Brown spot is another of the diseases that must be combated through crop rotation. Once the disease is present in a field, the planting of successive crops of soybeans will inevitably build it to damaging proportions. Brown spot is caused by the fungus *Septoria glycines* Hemmi. There are no resistant varieties.

Frogeye

Frogeye leafspot is a fungus disease that appears infrequently in Illinois. It is considered a minor disease. Frogeye appears rather late in the season, and is usually confined to the central and southern parts of the state. Although frogeye affects other parts of the plant, the conspicuous phase of the disease is the "eye-spot" on the leaf composed of a gray-to-tan central area, usually bordered by a narrow, darker margin (Figure 17). The leaves, when badly infected, fall prematurely. The disease also affects the stems and pods, and is carried on the seed. Frogeye is caused by the fungus *Cercospora sojina* Hara.

Diseased leaves and stems in the field carry the fungus through the winter and furnish spores for new infections in the spring. Infected seed germinate poorly and may produce weak seedlings. Spores produced on the cotyledons of infected seedlings are a source of further infection.

Two races of the fungus have been reported from Indiana. Race 1 has been known for many years; race 2 was discovered in 1959. The varieties Beeson, Cutler, Cutler 71, and Kent are resistant to both races.

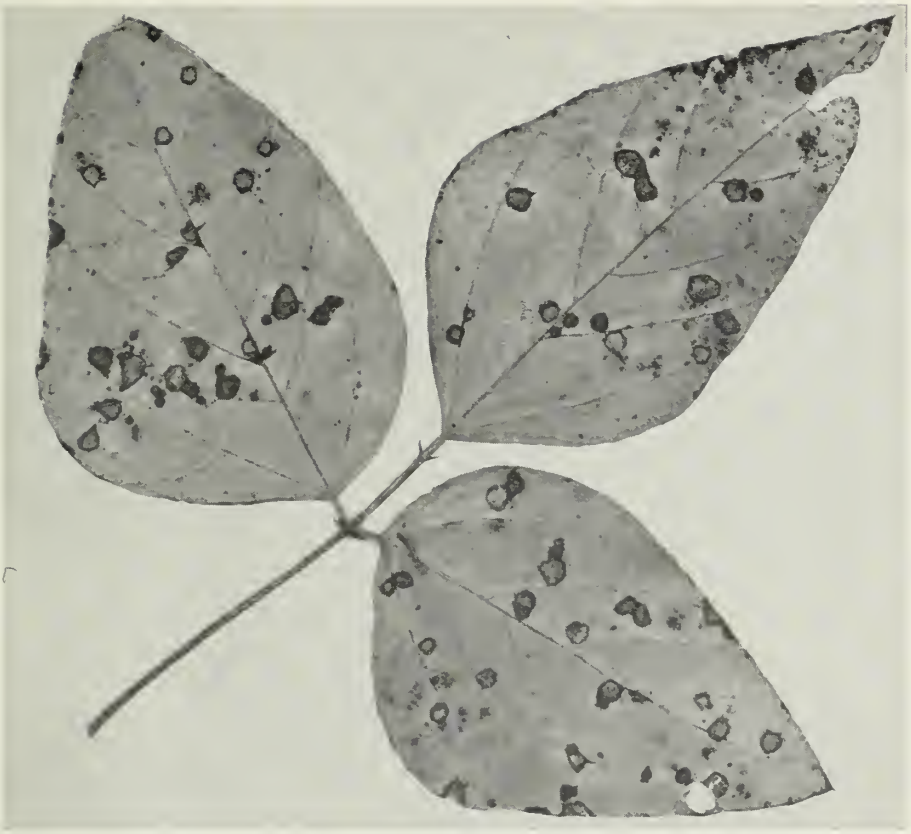

Figure 17. *Frogeye*. Typical lesions: gray-to-tan centers, darker margins. A minor disease in Illinois, frogeye is controlled by resistant varieties.

Downy Mildew

Downy mildew infects soybeans throughout Illinois. It is a fungus disease. The fungus first produces small, pale green spots visible on the upper surface of the leaf. These spots later become dark gray to brown (Figure 18). On the lower surface of the leaf, small, grayish tufts of moldy growth (conidiophores) develop on the spots (Figure 19). These conidiophores may drop off of old spots, leaving a brown spot similar to that on the upper leaf surface. The conidiophores are the most important diagnostic characteristic; after they have dropped off, the disease may be difficult to identify.

The spores (conidia) produced on the underside of the leaf serve to spread the infection to other plants throughout the growing season. Thick-walled resting spores (oospores) are produced in the tissues of the leaf and carry the fungus through the winter. These oospores may also en-

Figure 18. *Downy mildew*. The pale green spots on the leaflet at top are typical of early infection. The lesions on the other two leaflets are older, and the tissues are brown and dead. The leaflet at bottom has lost most of its green. Although widespread, downy mildew has not yet caused serious damage in Illinois. Varieties differ markedly in resistance.

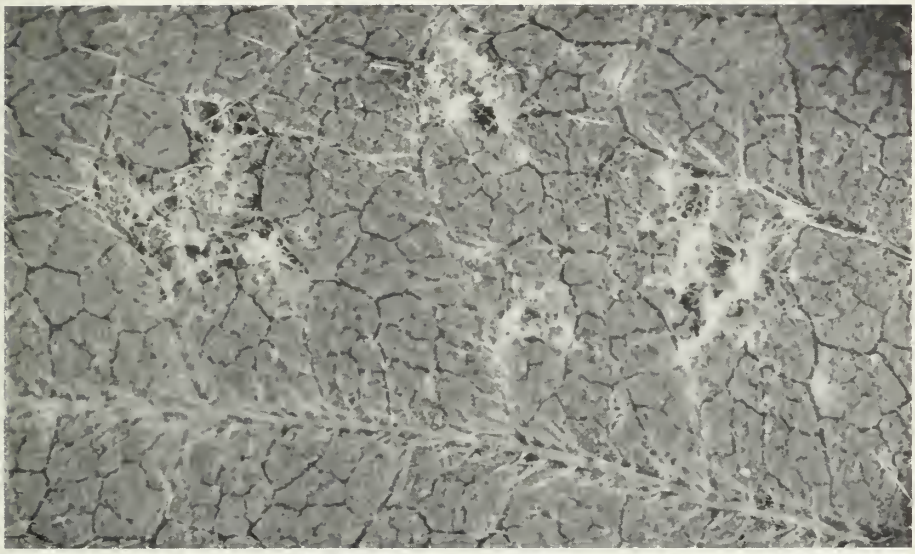

Figure 19. *Downy mildew.* This enlarged view (ten times natural size) shows grayish tufts of moldy growth on the lower surface of a leaf.

crust the seed and distribute the disease wherever the beans are planted. This seed sometimes produces plants that are apparently infected throughout with the fungus. The first and second pair of leaves to come out on these plants show large areas in which the green has disappeared.

Downy mildew is caused by the fungus *Peronospora manshurica* (Naum.) Syd. ex Gäum. Although this disease is widely distributed, it has not caused serious damage to soybeans in Illinois. The development of resistant varieties is complicated by the presence of races in the causal fungus. Twenty-three of these races have been identified. Sources of resistance to all races have been found at the Iowa Agricultural Experiment Station. Kanrich and Mendota varieties are resistant to all known races of the downy mildew fungus.

Alternaria Leafspot

Alternaria leafspot is a fungus disease fairly common in Illinois during the latter part of the growing season. It is caused by a species of *Alternaria.* The large, dark brown spots show concentric rings (Figure 20).

The disease was quite prevalent in Illinois in 1930, 1937, and 1947. Since 1947, it has varied in prevalence from year to year without causing much loss. The organism is generally considered to be a weak parasite, attacking the plants too late in the season to cause serious damage.

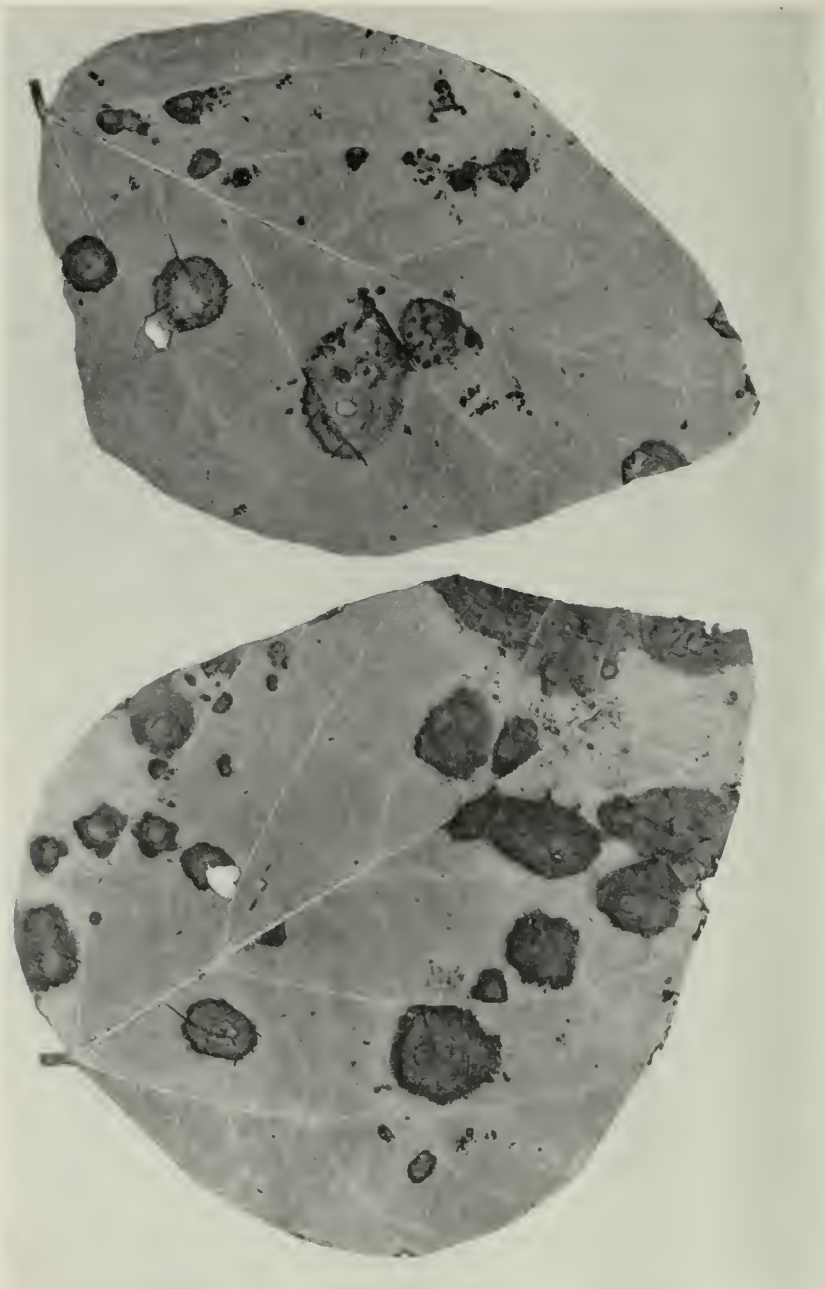

Figure 20. *Alternaria leafspot*. Note the concentric rings on the dark brown lesions. This disease usually appears too late in the season to cause much damage.

SEED AND SEEDLING DISEASES

Several disease organisms are carried in or on the seed. The oospores (resting spores) of the downy mildew fungus sometimes form a white crust on soybean seed. The purple stain disease caused by the fungus *Cercospora kikuchii* (T. Matsu. and Tomoyasu) Chupp. appears as a purple blotching of the seed. Grading standards will not permit more than 5 percent purple-stained seed in No. 1 yellow soybeans.

In some years, a dull brown discoloration of the seed has been associated with *Alternaria.* Many of the diseases previously described are seedborne, but they do not induce visible symptoms on the seed. High percentages of seed mottled by mosaic infection may be downgraded because the black or brown color in the seedcoat is objectionable to certain buyers in foreign trade, where most soybeans are used in food products.

In the southern part of Illinois, seed quality in some years is very poor. The seed may be shriveled, discolored, or covered with a grayish white growth of mold. Germination is low even in seed that appears to be undamaged. Moist, unfavorable weather conditions while the crop is maturing contribute to this problem. The fungus most frequently involved is the pod and stem blight organism, *Diaporthe phaseolorum* var. *sojae.* The germination of this seed may be improved by chemical seed treatment if the embryo is alive. The shrunken, moldy seed will not germinate even after seed treatment.

MINERAL DEFICIENCIES

Certain mineral deficiencies cause symptoms that are likely to be mistaken for the symptoms of diseases of parasitic origin. The mineral deficiency most commonly found in Illinois is potash deficiency. When soil is low in potash, a yellow mottling appears around the edges of the soybean leaflet, and the tissues at the margin become brown and brittle (Figure 21). The breaking up of the dead tissues gives the leaflets a ragged appearance. The central area of the leaflet remains green, but from a distance the affected areas have a distinctive yellow appearance. This condition is especially common in southern Illinois.

Although uncommon, iron deficiency occurs occasionally in Illinois. When soybean plants suffer from iron deficiency, the area between the veins fades from normal green to yellow. The tissues around the veins remain green. Later, the entire leaflet becomes yellow. The symptoms appear first on the top leaves.

Figure 21. *Potash deficiency.* A yellowing of the leaves and marginal browning is symptomatic of potash deficiency. This yellowing progresses from the tip and sides of the leaflets.

The leaves of soybean plants suffering from manganese deficiency closely resemble those of plants with an iron deficiency. This similarity makes it difficult to distinguish between the two conditions by their symptoms. A chemical test of the live plants may be necessary for accurate diagnosis.

SEED TREATMENTS

Thus far the results of experimental seed treatments do not warrant a general recommendation for their use as a disease control measure. The trials have usually shown that seed treatment on good-quality seed did not increase the yield significantly.

Under certain conditions, however, seed treatment may be beneficial. If, for example, the quality of the seed is poor, and it is consequently low in germination, seed treatment to increase stands may be profitable. Similarly, if seed supplies are short and planting rates are reduced to one-half bushel per acre or less to stretch the supply, seed treatment is probably justified.

The subject of soybean seed treatment has been somewhat confused by interpretation of experimental trials. In many experiments, treated seed has shown a 10- or 12-percent increase in stand over untreated seed but no increase in yield. These results are commonly obtained with rowed planting at the rate of one bushel per acre. The explanation is that soybeans can vary considerably in stand without showing a difference in yield. For example, increasing the best planting rate 25 or even 50 percent does not increase the yield. In general, growers in Illinois plant enough seed to permit some loss in stand to be absorbed without any decrease in yield. Under these conditions, the expense and labor involved in seed treatment does not seem justified.

It appears, then, that the usual rate of planting (one bushel per acre) may put more seed in the ground than is necessary for the highest yields. This is probably true if conditions are favorable at the time the seedlings are coming up. If the soil has crusted, however, the larger number of seedlings in the row are desirable because they can exert more force and break through the ground more easily.

It is not definitely known whether seed treatment has a bad effect on nodule inoculation. Although experiments at the Illinois Agricultural Experiment Station and elsewhere have shown that seed treatment has not killed all the bacteria with which the seed were inoculated, the treatment did appreciably reduce the number of nodules obtained from inoculation. In a considerable number of experiments in the field, however, plants from treated seed were as well nodulated as those from untreated seed, regardless of whether the seed had been inoculated. In these experiments, the nodule bacteria were in the soil, and seed treatment had no adverse effect on them.

Treatment of soybean seed with a fungicide may be advisable under unusual conditions — for example, when the seed has suffered from weather damage. In that case, inoculation with nodule bacteria may as well be omitted. This procedure of treating and omitting nodule bacteria is recommended only when well-nodulated soybean plants have grown on the soil recently. It seems best to make a choice — either to inoculate or treat with a fungicide — but not to do both.

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